PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference ACH63467WO00	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/GB2004/003242	International filing date *(day/month/year)* 28.07.2004	Priority date *(day/month/year)* 30.07.2003
International Patent Classification (IPC) or national classification and IPC C02F1/44		
Applicant UNIVERSITY OF SURREY et al.		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 7 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 4 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☒	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
27.05.2005	20.07.2005
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Goers, B Telephone No. +49 89 2399-7343

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/GB2004/003242

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages	
1-60	as originally filed
Claims, Numbers	
1-19	received on 27.05.2005 with letter of 26.05.2005
Drawings, Sheets	
1/6-6/6	as originally filed

   ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/GB2004/003242

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-19
	No:	Claims	
Inventive step (IS)	Yes:	Claims	5,6
	No:	Claims	1-4,7-19
Industrial applicability (IA)	Yes:	Claims	1-19
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V.

1 The following documents are referred to in this communication:

D1 : US 5 281 430 A (HERRON JOHN R ET AL) 25 January 1994 (1994-01-25)
D2 : US 3 532 621 A (HOUGH WILLIAM THOMAS) 6 October 1970 (1970-10-06)
D3 : WO 97/18166 A (OSMOTEK INC) 22 May 1997 (1997-05-22)
D4 : US 4 781 837 A (LEFEBVRE MICHEL S M) 1 November 1988 (1988-11-01)
D5 : WO 99/39799 A (MCGINNIS ROBERT L) 12 August 1999 (1999-08-12)

2 Novelty

2.1 The principle of the direct or forward osmosis process is well known in the art as a method of separating solvent from an osmotic solution. Documents D1-D5 are examples of typical embodiments and applications. It is an compulsory feature that the membrane is dense for the respective solutes used on the permeate side (which are known as "osmotic agents"). To subsequently separating the resulting permeate mixtures (osmotic agent and transferred solvent), different techniques are proposed in the prior art:

a) reverse osmosis (D3, fig.3/ D4, fig.2/ D5, abstract)
b) electrodialysis (D3, fig.6/ D2, col.6, ll 46-52)
c) evaporation (D1, fig.3)
d) precipitation, phase separation (D2, fig.)

2.2 The present application meets the criteria of Article 33(1) PCT, because the subject-matter of **claims 1-19** is not novel.

The differing feature to the prior art processes is the application of a nanofiltration for the recovery of the osmotic agent.

3 Inventive step

The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of **claims 1-4 and 7-19** does not involve an inventive step in the sense of Article 33(3) PCT.

3.1 Closest prior art document D4 discloses (the references in parenthesis applying to this document): A process for the desalination of seawater comprising a membrane module for osmotic distillation with a $MgSO_4$ osmotic agent second solution circulated in a recycle loop comprising a reverse osmosis extraction step (fig.2). The pressure resulting from the osmotic distillation increases the driving force of the reverse osmosis process. Fig.1 shows a different embodiment (fruit

juice concentration), where seawater is used as second solution. Seawater comprises both $MgSO_4$ and NaCl.

The differing feature to the subject matter of claim 1 is that for the recovery of the osmotic agent a reverse osmosis membrane is used instead of a nanofiltration membrane.

The problem to be solved is to lower the energy consumption of the recovery step.

The problem is solved by the application of a nanofiltration as the transmembrane pressure is considerably lower for achieving the same transmembrane flux.

At first it has to be stressed that the skilled man is well aware of the differences in between nanofiltration and reverse osmosis performance, i.e. in both terms of permeability and selectivity. It is further known that a nanofiltration membrane has a good capability to retain multivalent ions but a poor capabilitiy of retaining monovalent ions.

If (what is not yet disclosed in claim 1, see item VIII iii) osmotic agents are used which allow for being recovered by nanofiltration (such as magnesium sulfate) it would be the straightforward choice of the skilled man to apply them (as the operation pressure is lower). This principle is even disclosed in D4 (col.11, ll 19-23) "*... selecting a salt which ... has a large anion ... allows the choice of a more open membrane ...*".

In case of e.g. seawater is used as osmotic agent (see D4, fig.1) the use of a nanofiltration is not feasible due to the large amount of monovalent species in the agent.

Therefore the application of a nanofiltration is obvious to the skilled man and thus the subject matter of **claims 1 and 2** does not fulfil the requirements of Article 33(3) PCT in view of the disclosure of D4 and the knowledge of the skilled person.

3.2 The same argumentation is valid starting from document D3 as closest prior art. D3 discloses a direct osmosis process using salt or sugar as osmotic agents (p.7, ll 17-22) and being combined with one of the membrane processes reverse osmosis (fig.3) or electrodialysis (fig.6). Embodiments with series of direct osmosis

steps are further disclosed (fig.12&14).

The only differing feature to the subject matter of claim 1 is also that for the recovery of the osmotic agent a reverse osmosis membrane is used instead of a nanofiltration membrane.

Therefore the application of a nanofiltration is obvious to the skilled man and thus the subject matter of **claims 1 and 2** does not fulfil the requirements of Article 33(3) PCT in view of the disclosure of D3 and the knowledge of the skilled person.

3.3 The features of **claim 3, 7-14 and 16** are already disclosed by D3.

3.4 The features of **claims 17-19** are already disclosed by D4 (col.11, ll 15-32).

3.5 It is not clear, what problem is solved by the subject matter of **claim 4**. However D3 discloses already that the direct osmosis can be combined with various secondary technologies as evaporation, electrodialysis or ion-exchange (p.20, ll 5-8).
Thus an inventive step cannot be acknowledged for the subject matter of claim 4.

3.6 The use of antifouling agents according to **claim 15** is already obvious to the skilled person from the combination of the teachings of D4 and D1 (ex.4 discloses the use of the anti-fouling and anti-scaling agent Ultrasil).

3.7 The subject matter of **claim 5** discloses a further treatment of the residue of the nanofiltration.
The problem to be solved is to lower the energy consumption of the recovery process regardless of the composition of the osmotic agent.

As part of the osmotic agent can pass the membrane and will be found in the permeate of the nanofiltration, the further treatment is necessary. This is however no obvious choice of the skilled man starting from a reverse osmosis recovery process which already produces pure solvent in the permeate.

Therefore the subject matter of **claim 5** fulfills the requirements of Article 33(3) PCT.

Re Item VIII.

I **Claim 18** fails to indicate which of the membranes of claim 1 should have the defined pore size rendering the scope of the claim unclear (Article 6 PCT).

ii **Claim 19** fails to indicate which of the membranes of claim 1 should be the reference pore size for the solute size thus rendering the scope of the claim unclear (Article 6 PCT).

iii **Claim 1** is lacking essential features as the (at least partial) recovery of the osmotic agent only works if the pore size of the nanofiltration membrane is adjusted to the osmotic agent in the way as defined in claim 19. Thus the respective features should be introduced into claim 1.

CLAIMS

1. A process for removing a solvent from a first solution, said process comprising:

a) positioning a selective membrane between the first solution and a second solution having a higher osmotic potential than the first solution, such that solvent from the first solution passes across the membrane to dilute the second solution, and

b) extracting solvent from the second solution by passing the diluted second solution through a nanofiltration membrane, wherein the nanofiltration membrane is cast as a skin layer on a support, and the separation properties of the nanofiltration membrane are controlled by the pore size and electrostatic properties of the skin layer.

2. A process as claimed in claim 1, wherein the nanofiltration membrane is suitable for the separation of components that are 0.001 to 0.01 microns in size.

3. A process as claimed in any one of the preceding claims, wherein the second solution is prepared by introducing a known quantity of solute into a known quantity of solvent.

4. A process as claimed in any one of the preceding claims, which comprises dividing the diluted second solution from step a) into a first portion and a second portion, extracting solvent from the first portion by passing the first portion through the nanofiltration membrane of step b), and extracting solvent from the second portion by crystallization and/or distillation.

5. A process as claimed in claim 4, wherein the residue from the nanofiltration step b) is treated by a crystallization and/or distillation technique.

6. A process as claimed in claim 5, wherein the crystallization and/or distillation technique is selected from multi-flash distillation, multi-effect distillation, mechanical vapour compression, MED-thermo compression and rapid spray distillation.

7. A process as claimed in any one of the preceding claims, wherein the second solution is an aqueous solution comprising at least one of magnesium sulfate ($MgSO_4.6H_2O$ or $MgSO_4.7H_2O$), sodium sulfate ($Na_2SO_4.\ 10H_2O$), calcium chloride ($CaCl_2.2H_2O$ or $CaCl_2.6H_2O$), potassium alum ($24H_2O$), disodium hydrogenphosphate ($Na_2HPO_4.12H_2O$), glucose, fructose and/or sucrose.

8. A process as claimed in any one of the preceding claims, wherein the solvent of the second solution is the same as the solvent of the first solution.

9. A process as claimed in any one of the preceding claims, wherein the solvent of the second solution is water.

10. A process as claimed in any one of the preceding claims, wherein the first solution is a waste stream from an industrial or agricultural process or a domestic water stream.

11. A process as claimed in any one of claims 1 to 10, wherein the first solution is a saline solution.

12. A process as claimed in claim 11, wherein the saline solution is seawater or brackish water.

13. A process as claimed in any one of the preceding claims, wherein the elevated pressure induced in the second solution by the influx of solvent from the first solution is used to assist in the extraction of solvent from the second solution.

14. A process as claimed in any one of the preceding claims, wherein after solvent from the first solution passes across the membrane to dilute the second solution, the diluted second solution is contacted with one side of a further selective membrane and a further solution having a higher osmotic potential than the diluted second solution is contacted with the other side of the membrane, such that solvent from the diluted second solution passes across the membrane to dilute the further solution.

15. A process as claimed in any one of the preceding claims, wherein the second solution contains an additive selected from anti-scaling agents, corrosion inhibitors, anti-fouling agents and disinfectants.

16. A process as claimed in claim 15, wherein said second solution is circulated in a closed loop, such that said additives are reused.

17. A process as claimed in any one of the preceding claims, wherein the selective membrane of step a) has an average pore size of 5 to 50 Angstroms.

18. A process as claimed in claim 1, wherein the membrane has an average pore size of at least 10 Angstroms and the second solution contains solute species that are too large to pass through the pores of the membrane.

19. A process as claimed in claim 2, wherein the solute species in the second solution comprises at least one cationic species and/or at least one anionic species that is larger than the average pore size of the membrane.